Ministry of Forests, 518 Lake Street, Nelson, British Columbia V1L 4C6

A Retrospective Investigation of Partial Cuts In the ICHmw1and ICHmk1 In the Golden Forest District

D. L. DeLong RPF

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Forest Sciences Section
Ministry of Forests
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ABSTRACT

Relationships between regeneration density and various stand and site factors were explored in 10 partially cut blocks in the ICHmw1 and ICHmk1 subzones of the Golden Forest District. The blocks were harvested between 4 and 12 years ago. Residual basal areas ranged from 2.4 m^2 to 38m^2. The majority of blocks sampled in this investigation had abundant regeneration and could be considered satisfactorily restocked. Regeneration density and time since harvest were significantly correlated regardless of post harvest treatment regime. Few other significant correlations were found.

Many site and stand factors can interact together to influence natural regeneration success. From observations made during this study it was concluded that shelter may not have been a requirement for natural regeneration establishment on the sites sampled. Other factors such as brush potential and site preparation may have more influence on regeneration establishment than the shelter provided by a residual basal area in the ICH. The influence of a residual overstory seems to be seed supply. Exceptions may include sites that have severe moisture deficits (steep south facing slopes) or frost prone areas. With more pressure to use alternatives to clearcutting, partial cutting is being used more frequently. On most sites in the ICH, residual basal area levels used will likely be more a function of seed crop, block size, and objectives for aesthetics and/or wildlife habitat than shelter.

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INTRODUCTION

Forest practices in British Columbia have come under public scrutiny in recent years. As most of the public criticism has been focused on the practice of clearcutting, there is more pressure to use alternative cutting methods or "partial cutting" methods. Partial cutting has been used in the Nelson Forest Region since the turn of the century (Vyse and DeLong 1994). The primary objective of older partial cuts has been to remove a particular product, with little regard for regeneration. More recently, partial cuts have been prescribed to salvage lodgepole pine or western whitepine from mixed stands, with few prescriptions designed specifically for regeneration. Currently partial cuts are being prescribed to meet a variety of objectives such as aesthetics, watershed protection, and biodiversity. However, information on natural regeneration dynamics beneath a residual overstory is scarce.

Butt and Bancroft (1990) completed a retrospective study which documented regeneration success beneath 40 partially cut stands within the ICHdw and ICHmw2 subzones in the Kootenay Lake and Arrow Forest Districts. They concluded that natural regeneration was abundant in the partial cuts they sampled. They also recommended further retrospective studies be completed in different subzones. In the ICHmw1 and ICHmk1 subzones of the Golden Forest District there are also several recently harvested sites that could be described as Douglas-fir shelterwood or seed tree silvicultural systems. In an attempt to verify and compare some of Butt and Bancroft's (1990) findings in other ICH subzones, this retrospective study was completed with a similar approach. The objective of this study is to explore relationships between regeneration density and various stand and site factors beneath a range of residual overstories in the ICHmw1 and ICHmk1. Smith (1993) stated that neither regeneration methods nor silvicultural systems should be viewed as researchable treatment effects. He warned that experiments with silvicultural systems will not produce results that will enable anyone to state what the outcome of a partial cut in a given location will be. Rather, further projects should be focused on the "why" and not simply the "what" (Smith 1993). With this in mind, retrospective studies are a logical and efficient first step to *generate* hypotheses to test under more rigorous scientific methods.

METHODS

In July of 1992, 10 blocks from the ICHmk1 and ICHmw1 in the Golden Forest District were sampled. Each block met the following criteria :

1. The block was partially cut (i.e. some portion of overstory reserved from harvesting).

2. The block was harvested between 4 and 15 years ago. The lower limit was used to ensure that some regeneration was present on site. The upper limit of 15 years was set to ensure more accurate history record information.

3. The opening was at least five ha in size.

At each sample block, 15 systematically located plots were assessed. At each plot, measurements were taken on a set of three subplots in a nested configuration (Figure 1).

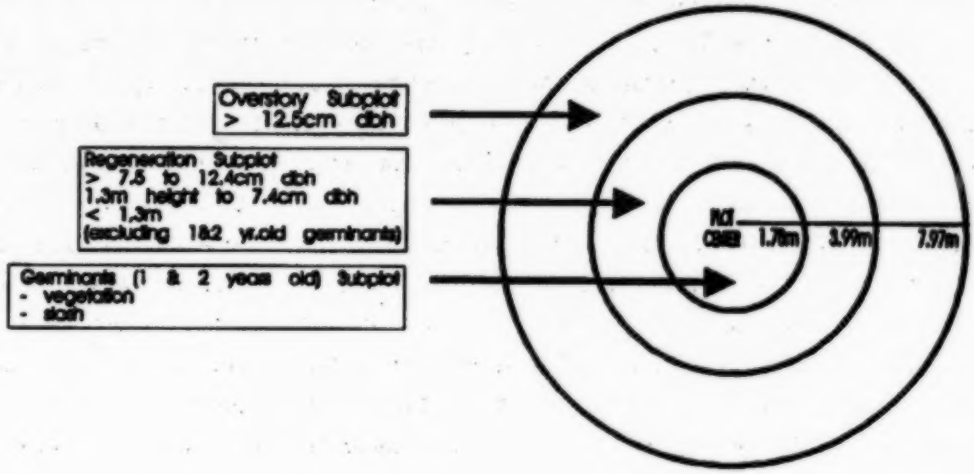

Figure 1. Plot configuration at each sample point

Measurements collected at each subplot:

1. Overstory subplot (r=7.97m)
   for all stems ≥ 12.5cm dbh:
   - -number, species, dbh, height, age
   - -occular estimate of % crown closure
   - -logging damage, armillaria incidence noted
   - -count and measure diameter of stumps
   - -count blowdown originating in plot
2. Regeneration subplot (r=3.99m)
   for all stems by class: ->7.5 to 12.4cm dbh (layer 2),
   -1.3m height to 7.4cm dbh (layer 3),
   -<1.3m height (layer 4, excluding 1 and 2 year old germinants):
   - -total trees, well spaced stems
   - -origin, species, height, age, leader growth, condition
3. Germinant/Vegetation subplot (r=1.78m)
   for germinants (≤ 2 years old):
   - -number, species, height, condition
   - -seedbed (mineral, mixed, undisturbed)

   for vegetation and slash:
   - -occular estimate of % cover
   - -modal height of vegetation

Aspect, elevation, slope, site series, soils texture, and site history were collected or verified for each block.

Data Analysis

Correlation analysis was used as the primary method of analysis to determine the degree of association between variables (Appendix 1). Significant associations do not indicate cause and effect, it can merely lead to reasoning about causal relationships between variables and subsequent hypotheses development. Analysis of variance was also used to test for significant difference between variable means, where appropriate. In order to consider within block variability, the data were summarized by block first.

STUDY SITES

Table 1 provides descriptions of the 10 blocks. Four blocks were located in the ICHmw1 and six blocks were located in the ICHmk1. The range of residual basal areas (RBA) between blocks was not as wide as originally desired, seven blocks had less than 10m2 RBA. Block 2 had over 35m2 RBA. This block was prescribed as a commercial thinning operation, but it was surveyed to include information from a high RBA. All of the sites had silty loam soil texture, and low to moderate slopes. Aspect and elevation ranged, but all blocks were either in the ICHmw1 or the ICHmk1 on circum-mesic sites.

Table 1. Block Descriptions

Block	subzone	elevation (m)	area (ha)	aspect	soil texture	slope	harvest (year)	planting (year)	brush cover (%)(ht)	Leading brush spp.	slash cover (%)	RBA (m2)
1	ICHmw1	1550	40	NE	SiL	35	1985	1990	51(91cm)	fireweed	7	4.3
2	ICHmk1	850	23	W	SiL	10	1987	nil	72(31cm)	calmagrostis	5	38
3	ICHmw1	900	27	W	SiL	10	1979	nil	82(47cm)	sheperdia	7	12.2
4	ICHmw1	900	114	NE	SiL	25	1985	nil	70(41cm)	paxistima	25	4.32
5	ICHmk1	1300	21	W	SiL	35	1988	1990	47(34cm)	raspberry	36	4.08
6	ICHmk1	1250	41	W	SiL	30	1985	1990	64(27cm)	sheperdia	18	2.3
7	ICHmk1	1190	62	SE	SiL	25	1985	nil	77(36cm)	paxistima	16	7.6
8	ICHmw1	870	24	SW	SiL	15	1987	1984	73(29cm)	sheperdia	10	3.4
9	ICHmk1	965	8	flat	SiL	5	1988	nil	78(22cm)	thimbleberry	21	10.12
10	ICHmk1	970	193	flat	SiL	5	1982	nil	75(29cm)	thimbleberry	7	7.62

Information collected on the stumps was summarized to reconstruct basal area, stems per hectare, leading species, and average diameter at the time of harvest. Lodgepole pine was the leading species at the time of harvest in the majority of blocks (Table 2).

Table 2. Reconstructed *pre*-harvest stands

Block	Basal area (m2)	Stem/ha	Leading spp	Average dbh (cm)
1	60.7	487	Se 6Bl3Fd1	37.0
2	43.5	683	Fd 6Pl2At2	27.6
3	44.0	643	Pl 7Fd2Se1	28.3
4	35.5	687	Pl 9Fd1	24.8
5	62.0	724	Se 4Pl3Bl1Fd1Cw1	30.5
6	35.4	749	Pl 9Fd1	22.9
7	36.8	657	Pl 7At2Se1	25.6
8	22.0	450	Pl 9FdSe1	24.4
9	44.5	783	Pl 6Se3Fd1	25.6
10	38.0	640	Se 5Pl3Fd1	26.1

RESULTS

The majority (82%) of the trees in the regeneration layer across all blocks were established post harvest. Post harvest regeneration (naturals) also made up 60% of all the well spaced stems (Table 3). Advance regeneration made up 13% of the total regeneration and 11% of the well spaced stems. Planted trees made up 5% of total regeneration and 29% of the well spaced stems. Species composition of the natural regeneration generally reflected the species composition of the residual overstory, with the exception of Blocks 1 and 7 (Tables 3 and 4). About one half of the total advance regeneration was subalpine fir, followed by cedar, spruce, and paper birch. Four of the sampled blocks were planted (Block 1, 5, 6, 8) with Douglas-fir or spruce. With the exception of Block 6, each of these planted blocks had well over 10 000 stems per hectare of regeneration and germinants present at the time of this investigation.

Table 3. Regeneration.

	Total regeneration						*Well spaced regeneration*	
Block	#/ha (all origins)	%natural/ advance/planted*	Leading spp (naturals)	Average leader growth naturals (cm)	Years since harvest	#/ha	%natural/ advance/planted	germinants /ha
1	6,200	50/35/15	Bl7Fd3	4	7	1,147	10/10/80	12,000
2	1,700	65/35/0	Fd7Se2At1	6	5	333	70/30/0	1,933
3	11,600	100/0/0	Fd7Pl1Se1At1	12	12	1,147	95/5/0	5,300
4	10,400	97/3/0	Fd7Cw1Pl1Se1	14	7	987	95/5/0	4,000
5	3,400	30/30/40	Fd4Pl3Bl3	5	4	1,040	5/5/90	6,700
6	1,800	35/5/60	Fd5Pl2Bl2Cw1	18	7	1,067	10/5/85	500
7	2,300	75/25/0	Pl6At3Ep1	17	7	400	80/20/0	500
8	14,500	99/0/1	Se4Fd3Cw2At1	14	12	1,160	90/5/5	4,500
9	2,500	50/50/0	Se4Pl3Fd1Bl1At1	7	4	693	50/50/0	1,900
10	14,500	95/5/0	Se7Ep2Cw1	12	10	1,133	95/5/0	4,000
Average	6 890	82/13/5	Fd4Se3Pl1Cw1At1	11	7.5	1000	60/11/29	4200

*naturals= regeneration established post-harvest
advance=regeneration established pre-harvest

Table 4. Characteristics of residual overstories.

Block	Basal area (m2)	%Crown closure	% of original basal area	Stems/ha	Leading spp	Average dbh (cm)
1	4.20	2	4	20*	Fd10	49.3
2	38.00	49	88	610	Fd 7At2Pl1	25.7
3	12.20	8	25	160	Fd 6Se3Hw2	29.2
4	4.32	5	7	50	Fd10	31.3
5	4.08	2	5	37*	Fd 8Se2	35.5
6	2.30	2	2	12*	Fd 8Se2	24.1
7	7.60	11	30	200	At7Pl2Fd1	21.1
8	3.40	3	12	53*	Se4Fd3Bl2Cw1	26.1
9	10.12	12	34	263	Se 4Fd3Ep2	20.9
10	7.62	11	23	150	Se 4Ep2Fd2At1	23.6

*planted blocks

When the blocks were stratified by subzone, the ICHmw1 had significantly more regeneration than the ICHmk1 with the exception of Block 10 (Figure 2).

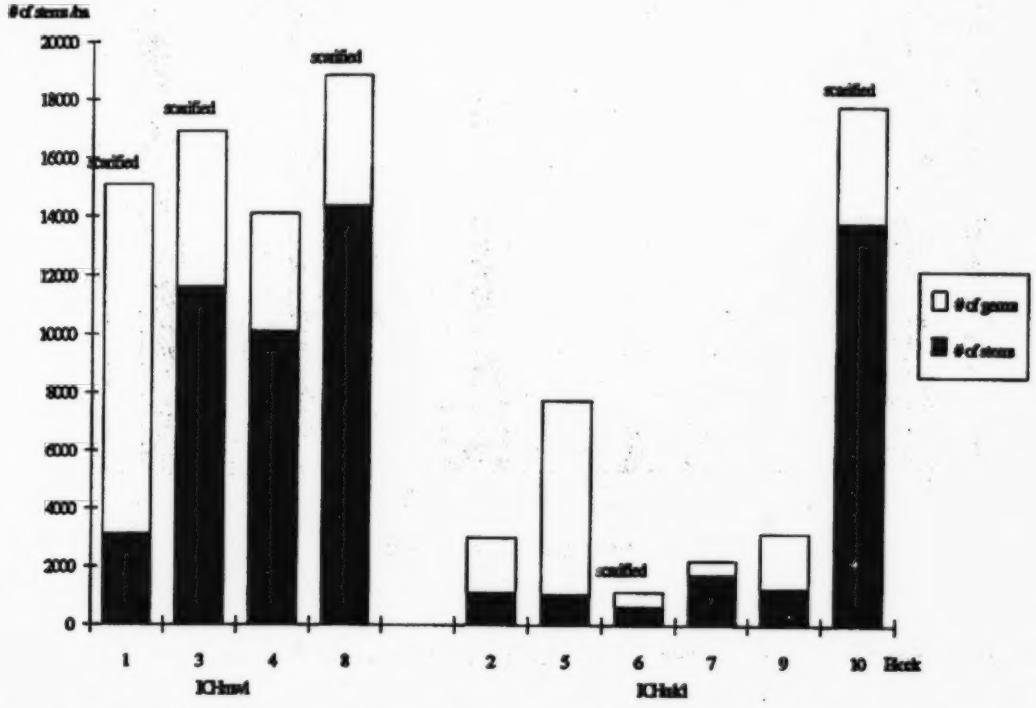

Figure 2. Post-harvest regeneration by subzone.

Scarified blocks were generally better stocked than unscarified blocks, with the exception of Block 6, but the difference was not significant (Figure 2). No significant correlations were found between regeneration density and vegetation cover or slash cover. Vegetation cover and number of germinants were negatively correlated (r=-.69). There was a significant positive correlation between the abundance of natural regeneration (r=.85) and well spaced stems (r=.80) with time since harvest (Figure 3).

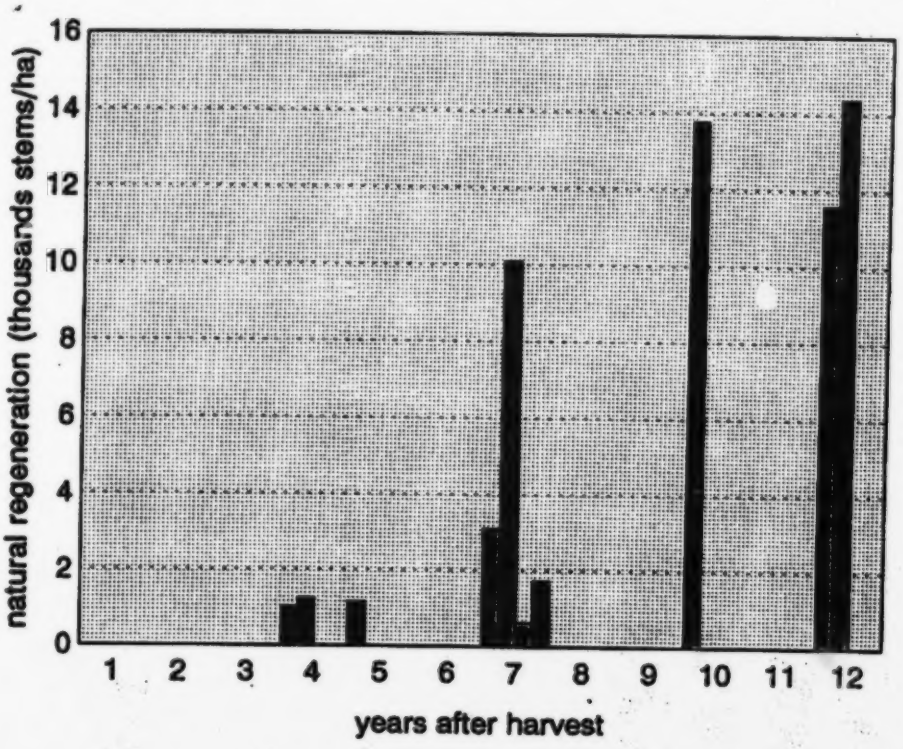

Figure 3. Number of stems per hectare over time since harvest.

For the blocks sampled, the gain in number of stems/hectare was greatest between 5 and 10 years after harvesting. This generally coincides with the regeneration delay (5 to 7 years) for natural regeneration on these sites (Braumandl and Curran 1992).

The residual basal areas sampled in this investigation ranged from 2.3 m^2 to 38 m^2 (Table 4). When the species profile of the blocks at the time of harvest are compared to the species profiles of the residual stands, it is evident that lodgepole pine was removed from most of the blocks in salvage operations (Tables 2 and 4). The general condition of the residual overstories were good, with little evidence of logging damage. Residual stems were usually co-dominant or dominant, with some stems exhibiting release since harvest. The average diameter of the overstory ranged from 21 to 49 cm (Table 4).

Overall, blowdown was rare. On the sites where spruce was more common in the overstory, there tended to be more blowdown. Although there were isolated Douglas-fir residuals with thinning crowns across all blocks, it was not confirmed as being caused by Armillaria (*Armillaria ostoyae).* Armillaria was not found in the regeneration layer, although it may be present as it can take up to 20 years for root contact to be made between regeneration and infected residuals and stumps (Morrison et al. 1991). The blocks sampled were all less than 15 years old. As expected, a significant, positive correlation was found between basal area and crown closure.

Both residual basal area (r=-.3) and residual trees/ha (r=-.25) were poorly correlated with natural (post harvest) regeneration density (Figure 4).

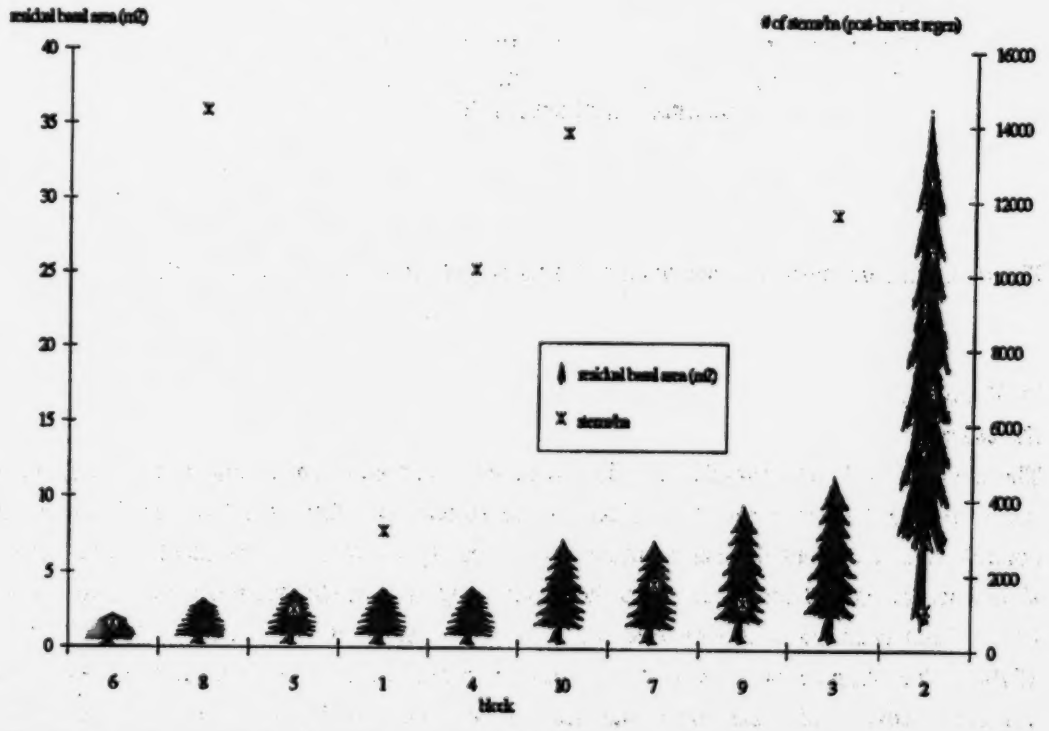

Figure 4. Regeneration density and basal area by block.

Increasing residual basal area had a significant negative relationship with regeneration leader growth (r=-.59) (Figure 5).

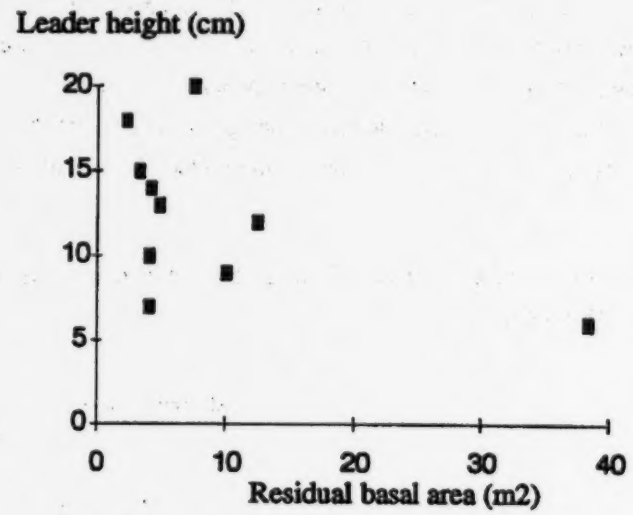

Figure 5. Residual basal area and average leader height growth (all regeneration).

DISCUSSION

Regeneration

The majority of blocks sampled in this investigation had abundant regeneration and could be considered satisfactorily restocked (SR). In the absence of other objectives, such as species control, it is questionable that planting was necessary on most of the blocks. The general abundance of natural regeneration on the blocks may be partially attributed to the low brush levels. Seed beds can stay receptive much longer on sites with low brush potential (Seidel 1979a). The absence of a relationship between regeneration abundance and percentage of vegetation cover and slash cover may also be attributed to the relatively low amounts of vegetation (50 to 80% cover, less than 1meter high) and slash (5 to 36% cover) present on the blocks.

The blocks sampled in the ICHmw1 had significantly more regeneration than the blocks in the ICHmk1 with the exception of Block 10. This relationship should be interpreted with caution as the sample size was small and time since harvest and site preparation may be confounding factors. Spring frosts are more common in the ICHmk1 and can damage flower and cone development. Therefore, less seed may have been available for regeneration. Frost may also have caused higher mortality of germinants. Block 10 had abundant regeneration despite being in the ICHmk1 subzone; it had been site prepared and it was the oldest of the blocks sampled in that variant.

Scarified blocks were better stocked than the unscarified blocks with the exception of Block 6. Adequate site preparation to expose mineral soil has been well documented as having a positive effect on natural regeneration success (MacDonald 1976a,1976b,1983; Hagner 1962; Shearer 1979; Seidel 1979a,1979b, Williamson 1983). For sites in western Oregon, Williamson (1973) suggests that the more mineral soil exposed the less basal area will be required to secure abundant regeneration. Although it was site prepared, Block 6 had a very low residual basal area (2.3 m^2/ha) on a fairly large cut block (41 hectares). Seed supply may have been limiting. As well, Block 6 was located in the ICHmk1 where as mentioned earlier, seed crops may be limited by frost.

There did not seem to be any direct relationship between block size (which ranged from 8 to 193 ha) and regeneration abundance. However there is likely interaction of block size and number of residual stems, through seed supply. For example, the larger the block, the more residual stems required to ensure adequate seed supply.

Advance regeneration was not protected during harvesting on any of the blocks, but surviving stems were often judged acceptable at the time of this study. In a recent problem analysis good release of advance regeneration was noted in all ICH subzones in the Nelson Forest Region (Still et al. 1988). The use of advance regeneration has also been advocated on sites with high brush potential as a means of keeping the site occupied (Seidel and Cochran 1981; Smith 1986). Advance regeneration is probably being under-utilized on many sites in the ICH.

Species composition

With the exception of two blocks (1 and 7), species composition of the natural regeneration generally reflected the species composition of the residual overstory. Butt and Bancroft (1990)

also found similar results. Block 7 had trembling aspen leading in the residual overstory but lodgepole pine was leading in the regeneration layer. Aspen reproduces well from root suckers after cutting the main stem. The aspen most likely did not sucker vigorously on Block 7, because it was left standing. In addition, aspen rarely reproduces from seed, is very shade intolerant, and will not grow well under a canopy (Burns and Honkala 1990). Aspen reproduces from suckering Block 1 was a transitional (to ESSF) high-elevation site and had more abundant subalpine fir regeneration despite the Douglas-fir overstory. Under these more severe site conditions (cool aspect and high elevation), subalpine fir germination was likely more successful than Douglas-fir germination (Burns and Honkala 1990). There may have also been more subalpine fir seed available as the adjacent stand had a large component of subalpine fir and there were few Douglas-fir seed trees (20 stems/ha) left on the block.

Residual basal area

Basal area (m^2) and number of residual stems/ha were poorly correlated with natural regeneration abundance. Several other studies did not find significant relationships between basal area and natural regeneration density (Butt and Bancroft 1990, Seidel 1979a, 1979b, 1983; Seidel and Cochran 1981). However, Seidel (1983) did find a significant correlation between overstory residual stems per acre and regeneration density (r=.76). Despite the absence of significant relationships between a measure of residual overstory and regeneration abundance, several researchers have found basal area to be a *contributing* factor in regression analyses (Butt and Bancroft 1990, Ferguson et al. 1986; Minore et al. 1984). Using regression analysis Ferguson et al. (1986) found the effect of basal area varied according to slope and aspect. Stocking on north aspects was not increased substantially by residual overstory density, while stocking on south aspects was increased by increased residual basal area. Haig (1941) also found similar results on his study sites in northern Idaho. Minore et al. (1984) found that in southwestern Oregon, regeneration improved on south aspects as basal area increased but only above 1800 feet. Butt and Bancroft (1990) found that north aspects had more abundant regeneration, but they did not report on how the effect of basal area might change with aspect.

Aspect did not appear to have an effect on regeneration abundance in this study. However, all of the blocks sampled were relatively flat (5 to 35%) which lessens the effect of aspect. Literature from the Pacific Northwest indicates that shelter is a requirement for successful regeneration establishment on sites that have severe moisture deficits (such as steep, south aspects) during the growing season (Tesch and Mann 1991). Residual shelter can also provide protection from frost

on relatively flat sites (Tesch and Mann 1991). In the ICH, where moisture deficits are less likely, shelter may not be a requirement for successful regeneration. However, it is unclear if frost was a factor in the ICHmk1 as mentioned earlier. Other factors such as brush potential and site preparation may have more influence on regeneration than shelter provided by residual stems. The influence of residual basal area seems to be mainly through seed supply on these sites.

Once regeneration is established, growth can be reduced by prolonged retention of the residual overstory. From this investigation, leader growth and increasing RBA were significantly negatively correlated. This effect is well documented in the literature (Atzet 1981; Ferguson et al. 1986; Haig 1941; Tesch and Mann 1991; Williamson 1973, 1983; Williamson and Ruth 1976; Minore 1977; MacDonald 1976a). In a study in north central California, after nine years, the height of Ponderosa pine, Douglas-fir and sugar pine in the clearcut was two times that of trees under the shelterwood. The extent of growth reduction is dependent on species and canopy density.

Several authors have suggested ranges of residual basal area (RBA) for shelterwood overstory densities in Washington, Oregon, and Northern California (Williamson 1973; Minore et al. 1984; Seidel 1979a; Seidel and Cooley 1974; Gordon 1979; Dunlap and Helms 1983; Seidel 1983; MacDonald 1976; Laacke and Tomascheski 1986; Oliver and Dolph 1990). The numbers vary with geographic location, stand and site factors, and management objectives. Most recommendations are between 10 and 25m^2 per hectare, with some as low as 5m^2 and as high as 40m^2. RBA's of more than 40m^2 (or more than 50% of the original basal area) are likely too high to establish natural regeneration. Light is limiting for growth at these levels. The main influence of RBA on sites in the ICH seems to be through seed supply, therefore, levels will depend on block size or distance from adjacent seed source. In addition, some level of RBA may be required if some degree of species control is desired. Although inconclusive, sites in the ICHmk1 may benefit from RBA as protection from frost.

CONCLUSIONS

With more pressure to use alternatives to clearcutting, partial cutting is being used more often. The shift away from clearcut/plantation silviculture can be looked at as an opportunity for foresters and researchers to rediscover and fine-tune knowledge of natural regeneration. Given the results of this study and those of Butt and Bancroft (1990), we can rely on natural and

advance regeneration in the ICH more often than we currently do. More than 10 000 stems per hectare on 9 out of 10 blocks was achieved within an average of seven years. Stocking control may eventually be required on several of the blocks depending on free-to-grow regulations and product goals.

In general, residual basal area levels will be a function of:

- seed crop, block size,
- objectives for aesthetics and/or wildlife habitat,
- and whether or not there is risk of moisture deficit or frost (does not seem likely on most sites in the ICH).

From the results of this study rough guidelines for residual basal area levels are suggested:

ICHmw1	ICHmk1
5-15m2 /ha for seed supply	5-15m2/ha for seed supply
15-25m2 /ha for steep south facing slopes for moisture deficit protection	15-25m2/ha on flatter slopes for frost protection or steep south facing slopes for moisture deficit protection

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APPENDIX 1

Correlation analysis.

	residual basal area	crown closure	post-harvest regen	well spaced	leader ht	time since harvest	germinants	vegetation cover	slash cover
residual basal area	1.00								
crown closure	**0.91**	1.00							
post-harvest regen	-0.30	-0.22	1.00						
well spaced	-0.22	-0.10	**0.95**	1.00					
leader ht	**-0.59**	-0.32	-	0.36	1.00				
time since harvest	-	-	**0.85**	**0.80**	0.50	1.00			
germinants	0.05	-0.34	0.07	-0.05	-0.55	0.06	1.00		
veg cover	0.01	0.32	0.40	0.59	0.48	0.41	**-0.69**	1.00	
slash cover	-0.42	-0.39	-0.37	-0.39	-0.03	**-0.56**	-	-0.43	1.00
# residual stems/ha			-0.25						

Bold denotes significant correlation at 95% confidence level